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(54) **Roller tooth bit with heel row cutter inserts.**

(57) A milled tooth rotary cone rock bit, as it is operated in a borehole, brings the heel of each cone into contact with the borehole wall when the gage row milled teeth wear. The heel row of each cone is relieved and tungsten carbide chisel inserts (134) are equidistantly placed within the relieved heel recess. The heel row inserts cooperate with the gage row milled teeth (129) and progressively cut more of the gage of the borehole as the row of milled teeth on the gage of the cone wear. Moreover, the gage row milled teeth are partially hardfaced leaving relieved areas on the cutting side of each tooth to enhance the cutting action of the gage row of each cone.

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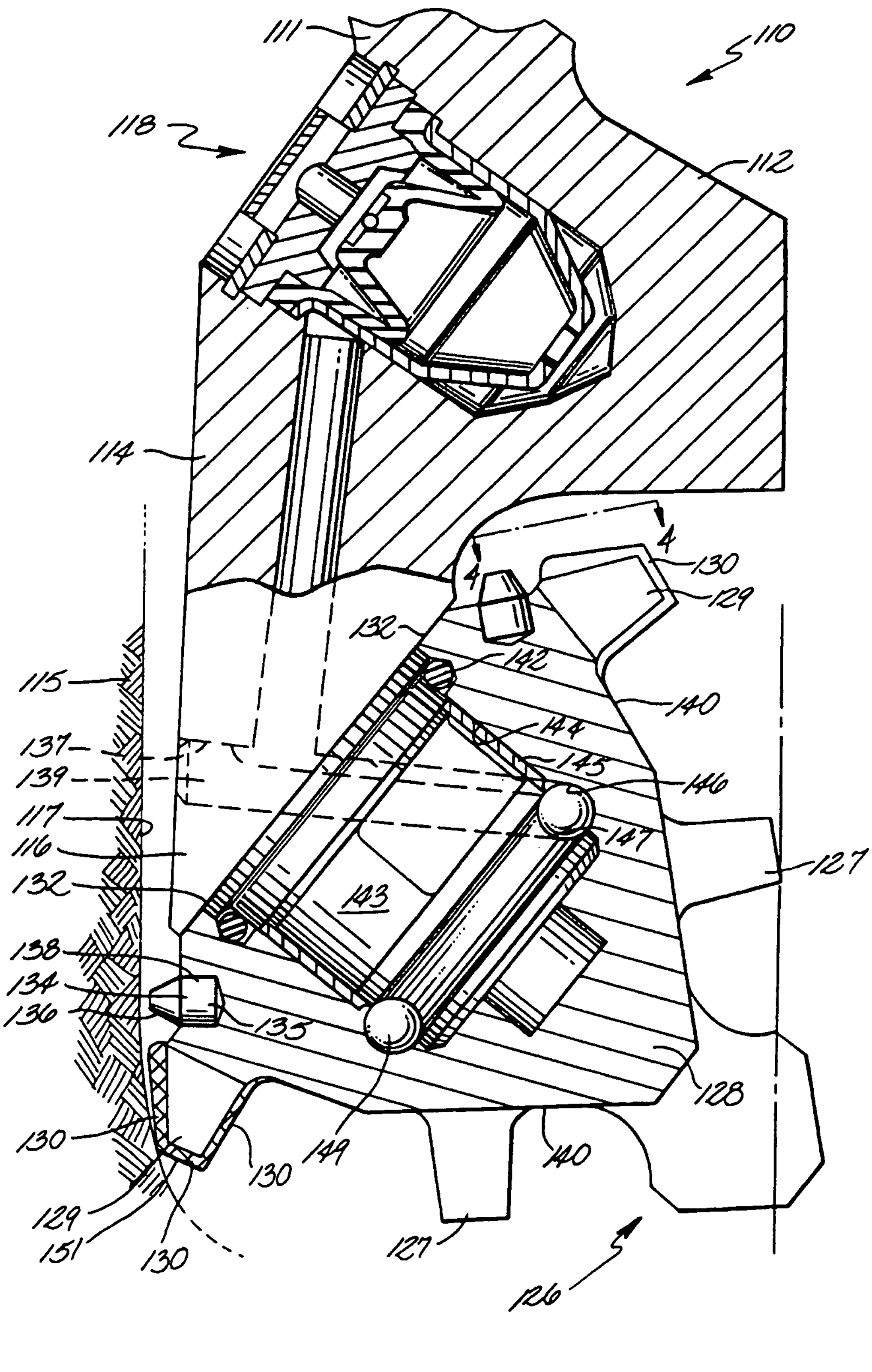
Fig. 3



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BACKGROUND OF THE INVENTION

This invention relates to sealed bearing milled tooth rock bits.

More particularly, this invention relates to milled tooth rotary cone rock bits, having tungsten carbide inserts dispersed in a heel row of each of the cones--the gage row milled teeth having partial hardfacing on the gage cutting side of each tooth.

Maintaining the gage diameter of an earthen borehole utilizing rotary cone rock bits is critical during operation of the rock bits in a borehole. If a rotary cone rock bit should become under gage or is worn to the point of cutting a hole diameter smaller than the original gage of the new bit, then subsequent full gage diameter rock bits will pinch and the rate of penetration will become less due to the under gage condition of the borehole.

Moreover, directional drilling has become more and more prevalent as the world oil resources become more scarce. Tapping into existing oil reserves or previously unattainable oil fields from a direction other than vertical is the most prevalent state-of-the-art method to most effectively utilize these resources. Rotary cone rock bits used in directional drilling are more subjected to bit side loads because the bit is forced to turn away from a straight or vertical penetration. Typically, a rotary cone is connected to a mud motor to drive the bit downhole. The gage rows of each of the rotary cones on the rock bit are more severely affected because of the side loads imparted to the bit during directional drilling operations.

State of the art milled tooth rotary cone rock bits utilized in drilling directional boreholes are less effective when the gage teeth wear. As the gage row teeth wear, the cutting of the gage or diameter of the borehole is compromised. In directional drilling operations, the gage row on each cone of the rotary cone rock bit must be sharp to allow the bit to change direction as it penetrates the formation. The increased area exposed by the worn gage row teeth gradually (as the bit wears) become bearing surfaces against the borehole peripheral sidewalls and it is increasingly more difficult to steer the bit in directional drilling operations.

The present invention addresses the method in which gage is cut in a borehole. Each of the milled teeth on the gage row of a milled tooth cone is partially hardfaced to extend beyond the core steel tooth on the cutting side of the tooth. The heel row adjacent to the gage row is relieved (recessed from the cone surface) and tungsten carbide or similar wear resistant inserts are equidistantly or randomly spaced in the recessed portion of the heel row. The tungsten carbide teeth act to cut the gage of the borehole as the gage row teeth wear. This configuration is particularly effective in directional drilling where side loads on the drill bit particularly affect the ability to maintain gage of the borehole.

Patent No. 3,134,447 teaches a tungsten carbide rotary cone rock bit having flush type tungsten carbide inserts imbedded in a heel row of each cone. The flush type inserts serve to prevent the heel portion of the bit from excessive wear, but does not aid in cutting gage as the rock bit works in a borehole.

Patent No. 2,774,571 illustrates a tungsten carbide rotary cone rock bit with extended tungsten carbide inserts in a gage of a rotary cone. The inserts in the gage are the primary gage cutting inserts and when they wear, the rotary cone bit will become under gage.

The present invention overcomes these disadvantages by providing enhanced gage cutting capabilities. This invention has particular application for drilling wherein the rotary cone rock bits are driven by a downhole mud motor during directional drilling operations.

BRIEF SUMMARY OF THE INVENTION

A rotary cone milled tooth rock bit comprises a rock bit body having a first pin end and a second cutting end. The body has at least one leg extending toward the second cutting end. The leg includes a journal bearing adapted to rotatively receive a cutter cone.

A conically shaped milled tooth cutter cone has a first open ended cylindrical cavity for receiving and rotating on the journal bearing, and a second cutter end. The cone has one or more rows of milled teeth in a surface of the cone. A gage row of milled teeth is positioned nearest the open end of the cone. The gage row milled teeth have hardfaced cutter surfaces formed thereon. A circumferential heel row groove recessed from the surface of the cone is on the cone between the gage row milled teeth and the cylindrical cavity.

A plurality of cutter inserts are secured within the recessed heel row groove. The inserts protrude from the recessed heel row and serve to cooperate with and maintain the gage of the rock bit after the gage row milled teeth wear during operation of the bit in a borehole.

An advantage then of the present invention over the prior art is the ability to maintain gage of a borehole even though the gage row milled teeth may be worn. Another advantage of this present invention over the prior art is the use of the dual gage cutting capability of the milled tooth bit particularly for directional drilling where the gage of the bit is constantly in contact with the formation when the bit is side loaded during operation.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and advantages

can be best understood from the ensuing description taken together with the appended drawings wherein like numerals indicate like parts.

FIGURE 1 is a partial cross-section of a prior art cone illustrating a single gage cutting row of milled teeth;

FIGURE 2 is an end view of a three cone milled tooth rock bit of the present invention;

FIGURE 3 is a view taken through 3-3 of Fig. 2 illustrating a partially sectioned leg and cone of a milled tooth rock bit;

FIGURE 4 is an enlarged view of the gage row milled teeth taken along 4-4 of Fig. 3 illustrating the recessed heel row with insert cutters equidistantly placed within the heel row recess; and

FIGURE 5 is a view taken through 5-5 of Fig. 4 illustrating the relationship between the gage row milled teeth, the recessed cutter inserts and the borehole side wall.

DETAILED DESCRIPTION

With reference now to the prior art of FIGURE 1, a state-of-the-art milled tooth cone 10 is shown assembled onto a journal bearing 12 cantilevered from the bottom of a leg 14 extending from a body of a milled tooth roller cone rock bit (not shown). A plurality of rows of milled teeth 16 project from the surface 17 of the cone 10. A gage row of milled teeth 18 are located adjacent a cylindrical bearing cavity 20 formed through the base 21 of the cone 10.

It is typical to machine a groove 19 on the cutting side of the gage row milled teeth 18. The groove or slot 19 is then filled with a hardfacing material 22 to bring each gage row tooth back out to the gage diameter of the cone 10. The hardfacing material 22 resists wear as the gage row teeth cut the gage 25 of an earthen formation 27.

As the gage row milled teeth wear, along with the hardfacing material 22, the gage 25 of the borehole will be reduced depending on the amount of wear of the gage row teeth 18. As the gage row teeth wear, the worn surface becomes more and more of a smooth bearing surface rather than a means to cut the gage, hence the gage cutting capability of the state-of-the-art milled tooth bit is compromised as heretofore stated.

With reference now to FIGURES 2 and 3, the sealed bearing milled tooth rotary cone rock bit generally designated as 110 comprises a rock bit body 112 with a threaded pin end 111 and a cutting end generally designated as 126. Each cone 128 associated with the cutting end 126 is rotatably attached to a journal bearing 143 extending from a leg 114 that terminates in a shirttail portion 116 (FIG. 3). Each of the cones has, for example, a multiplicity of substantially equally spaced milled teeth 127 protruding from the surface 140 of the cone 128.

A lubricant reservoir, generally designated as 118, is provided in each of the legs 114 to supply lubricant to bearing surfaces formed between a rotary cone bearing sleeve 145 and the respective journal 143. Three or more nozzles 113 (FIG. 2) communicate with a chamber formed inside the bit body 112 (not shown). The chamber receives drilling fluid or "mud" through the pin end 111 and the fluid then is directed out through the nozzles 113 during bit operation for cooling and removing chips of earthen formation.

A series of cemented tungsten carbide chisel-type inserts 134 are preferred and are positioned in a recessed heel portion 133 formed in the base 132 of the cone. Each insert 134 has a base end 135 and a chisel cutting end 136. The inserts are inserted within a circumferential recessed heel groove 133 formed between the milled tooth gage row 129 and a journal cavity 144 formed in the end 132 of the cone. It would also be possible to use protruding inserts other than chisel types without departing from the scope of this invention.

A series of equidistantly spaced insert holes 138 are formed within the groove or channel 133 in the base of the cone. The relieved recess channel 133 in the cone provides an annular space between the borehole wall 117 and the recess receiving the row of inserts. The chisel end 136 of the tungsten carbide inserts 134 protrudes from the recessed surface 133. The chisel end 136 is, of course, adjacent the wall 117 of the formation 115.

The milled gage teeth 129 have a partial layer of hardfacing material 130 such as tungsten carbide that provides the cutting surface adjacent the borehole wall 115 for each of the gage row milled teeth 129.

A patented hardfacing material (U.S. Patent No. 4,836,307) for milled tooth bits comprising a mixture of tungsten carbide particles and steel is a preferred hardfacing material for the present invention. The hardfacing material 130 partially encapsulates each of the gage row teeth. Gage row teeth 129 have hardfacing material along the gage cutting surface 153 adjacent the borehole wall 117, along the crown 151 and along an inner surface 155 on the inward face of each gage row tooth (FIGS. 4 and 5). The area of the tooth 141 which is not hardfaced is now recessed to ensure that the hardfacing material 130 adjacent the borehole wall 117 stays sharp and does the cutting of the gage during operation of the milled tooth bit in the earthen formation 115. Most of the tooth is encapsulated for wear resistance.

Referring specifically to FIG. 3, the cone is typically assembled over a journal bearing 143 cantilevered from the leg 114. The cylindrical journal bearing cavity 144 is bored out to accept, for example, a bearing sleeve 145 that freely rotates between the cone and the journal bearing 143. An O-ring 142 typically seals the area between the rotating cone and the jour-

nal to prevent lubricant from the lubricant reservoir 118 from escaping past the bearing surfaces formed between the cone 128, the sleeve 145 and the journal 143.

Cone retention balls 149 are inserted through a ball hole 137 formed through the shirttail 116 into a ball race 146 formed in the rotating cone and a ball race 147 in the journal bearing. The balls 149 retain the rotating milled tooth cone 128 on the journal 143. A ball hole plug 139 is inserted within the ball hole 137 after all of the ball bearings 149 are trapped within their respective races 146 and 147. The ball plug typically is welded through the shirttail portion 116 in the leg 114 after the milled tooth cone is assembled onto the journal bearing 143.

Referring now to FIGURE 4, a portion of the base 132 of the cone is shown to illustrate the circumferentially extending recessed portion 133 formed in the base of the cone between the gage row milled teeth 129 and the journal bearing cavity 144. A series of tungsten carbide chisel inserts 134 are pressed into insert holes 138 formed in the circumferential recess 133 in the heel portion of the cone.

The chisel crest or blade of the cutting end 136 of the tungsten carbide insert 134 is oriented within its insert cavity 138 such that the blade of the chisel crest is aligned substantially longitudinally with respect to an axis 150 of the cone 128. In other words, the long dimension of the chisel crest extends in the same direction as the axis of the cone. Moreover, each of the inserts 134 are about equidistantly spaced one from the other within the annular recessed portion 133 of the cone 128. This orientation of the heel row inserts prolongs the gage cutting life of these inserts.

Each of the gage row milled teeth 129 has hardfacing material 130 positioned on the tooth 129 such that the hardfacing material partially encapsulates each of the teeth 129. A portion 141 along a surface 153 on each of the gage row teeth 129 is recessed such that when the rest of the tooth is filled with hardfacing, the protruding hardfacing material 130 acts as the cutting surface of each of the gage row milled teeth 129. Hence, that portion of the gage row teeth 129 not covered by the hardfacing material 130 is recessed and would not interfere or become a bearing surface as the cones 128 rotate in a borehole. The gage of a borehole and the bit rate of penetration is thus maintained during operation of the milled tooth rotary cone bit in the earthen formation 115.

During operation of the bit in a borehole, the gage row milled teeth 129 cooperate with each of the tungsten carbide chisel inserts 134 to maintain the gage of the borehole as specifically illustrated in the enlarged segment shown in FIGURE 5. The tungsten carbide chisel inserts 134 and the gage row milled teeth 129 with hardfacing thereon perform as dual gage cutters and are uniquely suited to directional drilling applications where bit side loads are increased.

The enlargement of FIGURE 5 distinctly illustrates the cooperation between the milled tooth gage row and the tungsten carbide chisel inserts pressed into recessed portion 133 of the cone 128. The tungsten carbide hardfacing material 130 protruding from the surface 153 of the gage row teeth 129 engages the borehole wall 117 and the cutting ends 136 of the tungsten carbide inserts 134 also engage the borehole surface 117 of the earthen formation 115, thus most efficiently cutting the gage of the borehole during operation of the milled tooth bit in the borehole.

It will, of course, be realized that various modifications can be made in the design and operation of the present invention without departing from the spirit thereof. Thus, while the principal preferred construction and mode of operation of the invention have been explained in what is now considered to represent its best embodiments, which have been illustrated and described, it should be understood that within the scope of the appendant claims, the invention may be practiced otherwise than as specifically illustrated and described.

Claims

1. A rotary cone milled tooth rock bit comprising a rock bit body having a first pin end and a second cutting end, the body having at least one leg extending toward the second cutting end, the leg having a journal bearing for rotatably receiving a cutter cone, and a conically shaped milled tooth cutter cone having a first open ended cylindrical journal bearing cavity for rotating on the journal bearing, and a second cutter end, the cone further having one or more rows of milled teeth projecting from a surface of the cone, a gage row of milled teeth being positioned nearest the first open end of the cone, and characterized by:

   a circumferentially extending heel recess in the cone between the gage row milled teeth and the cylindrical journal bearing cavity; and

   a plurality of cutter inserts secured within the circumferential heel recess, the inserts protruding from the heel recess for cooperating with the gage row milled teeth for maintaining the gage of the rock bit after the gage row milled teeth wear during operation of the bit in a borehole; and wherein

   the gage row milled teeth are partially covered by hardfacing material, a portion of the gage row milled teeth without the hardfacing material being recessed from the hardfacing material, the hardfacing material comprising the cutting edge of the gage row milled teeth.

2. A rock bit as set forth in Claim 1 wherein the hardfacing material comprises tungsten carbide.

3. A rock bit as set forth in either of Claims 1 or 2 wherein the plurality of cutter inserts are cemented tungsten carbide inserts imbedded in insert holes formed in the heel recess in the cone.

4. A rock bit as set forth in any one of the preceding claims wherein the inserts are chisel type cemented tungsten carbide inserts having a first base end inserted in holes in the cone and a chisel shaped second cutter end protruding from the cone surface.

5. A rock bit as set forth in any one of the preceding claims wherein the second cutter end of the chisel insert has a long dimension oriented substantially longitudinally with respect to an axis of the cone.

6. A rock bit as set forth in any one of the preceding claims wherein each of the inserts is substantially equidistantly spaced one from the other within the circumferential recessed heel row of the cone.

Fig. 2

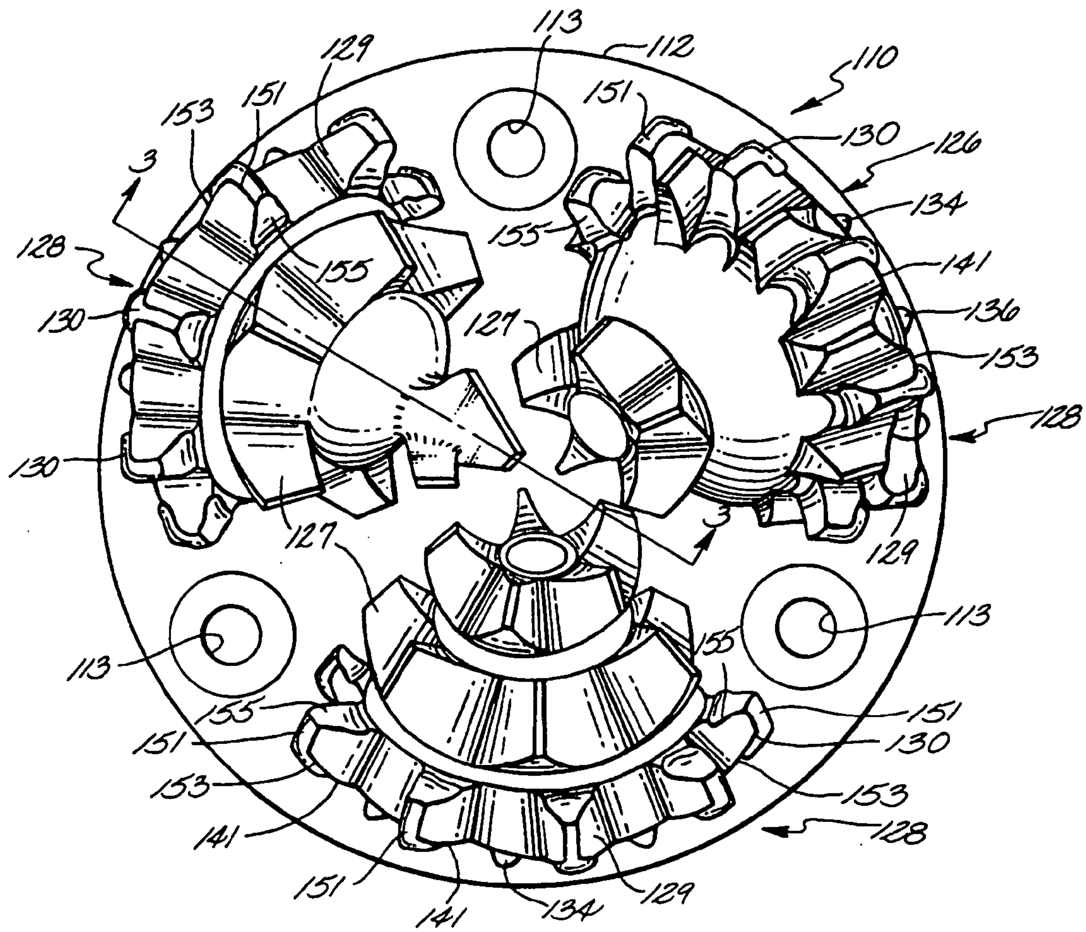

Fig. 1
PRIOR ART

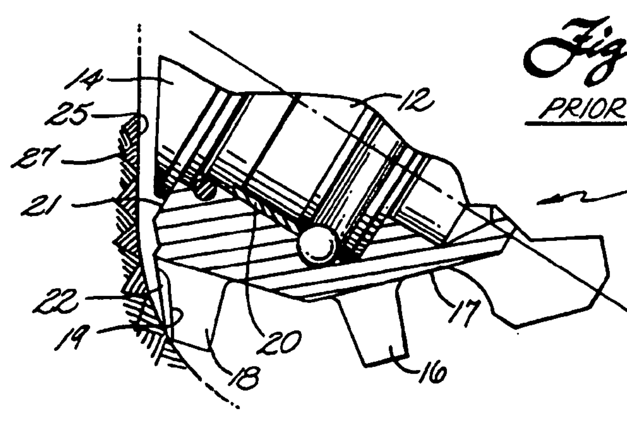

Fig. 3

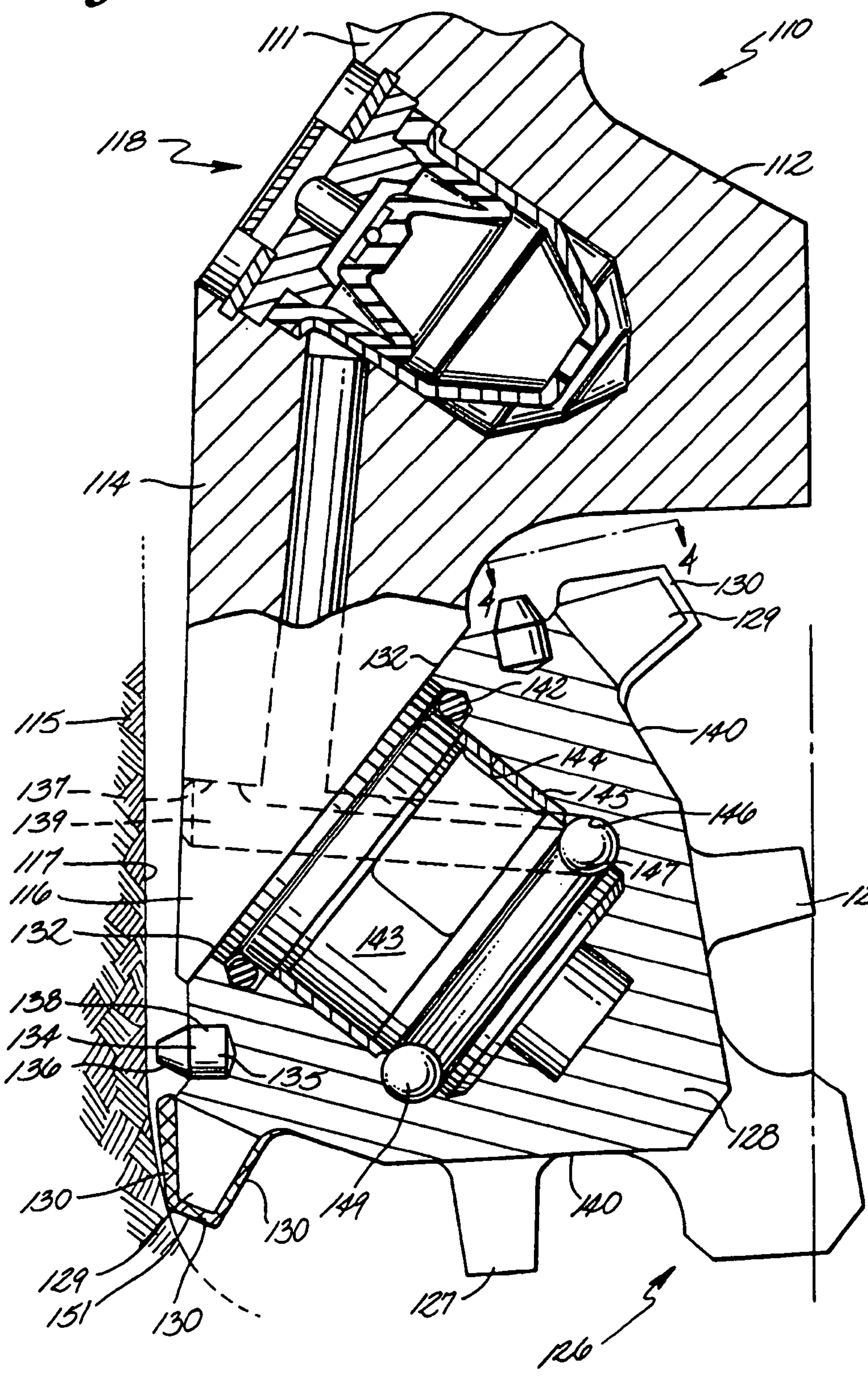

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Fig. 5

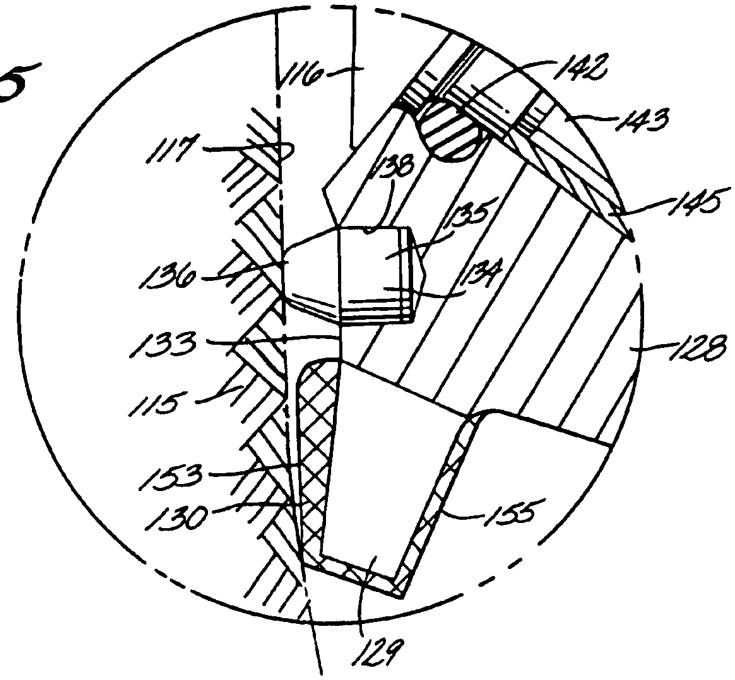
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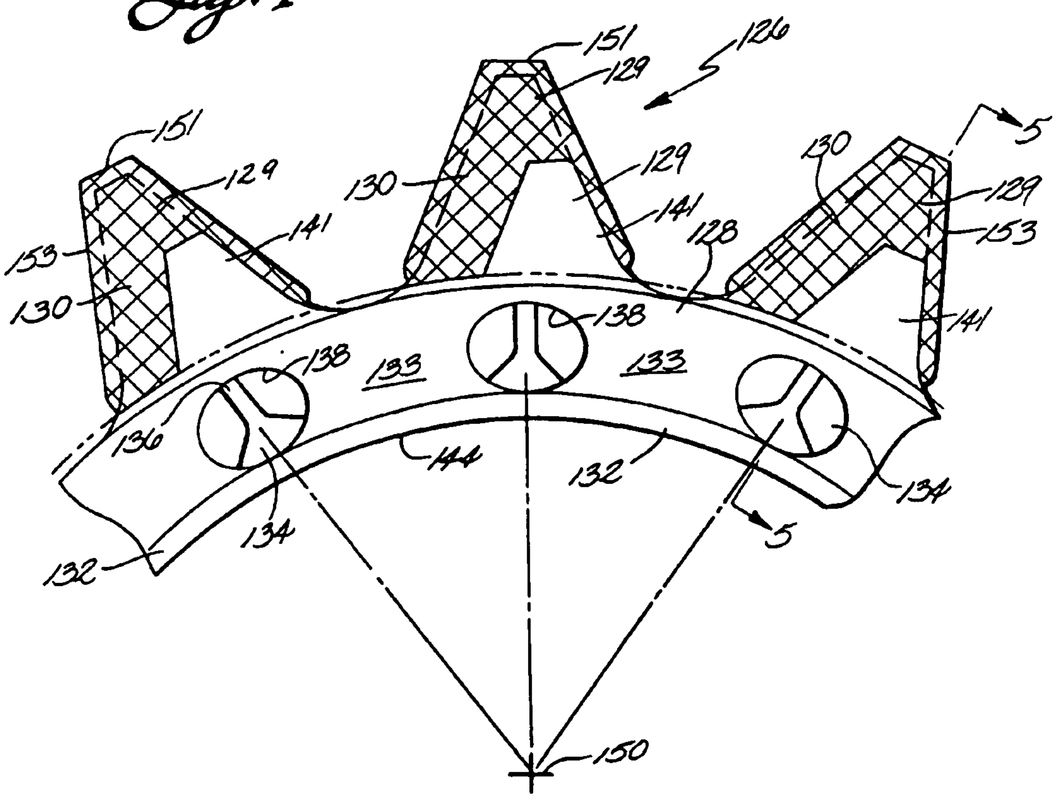
Fig. 4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European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 85 0174

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	DE-B-1 046 544 (HUGHES TOOL CO.) * column 3, line 36 - column 4, line 5; figure 3 *		E21B10/16 E21B10/50
A	US-A-3 696 876 (E.G.OTT) * column 3, line 41 - line 47; figure 4 *		
D,A	US-A-4 836 307 (M.K.KESHAVAN ET AL.) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	31 OCTOBER 1991	RAMPELMANN K.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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